AGILE: GIScience Series, 4, 14, 2023. https://doi.org/10.5194/agile-giss-4-14-2023
Proceedings of the 26th AGILE Conference on Geographic Information Science, 2023.
Editors: P. van Oosterom, H. Ploeger, A. Mansourian, S. Scheider, R. Lemmens, and B. van Loenen.
This contribution underwent peer review based on a full paper submission.

Active teaching and learning in GI sciences: lessons learned from the BSc. Course Open Urban Data Governance

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Abstract. A new active teaching and learning approach has been implemented in the BSc course Open Urban Data Governance.. This course is part of the minor Spatial Computing for Digital Twinning in the Bachelor of Architecture, Urbanism and Building Sciences at the Faculty of Architecture and The Built Environment, TU Delft, and offered TU wide as an elective. At the start of the course the students were tasked to collect and analyse noise level data, and to reflect on this process. In the second (main) assignment they had to develop an urban challenge to be answered with geo-data. Also here a reflection was required including an assessment of the FAIRness of the data. Both students and teachers highly appreciated the new approach. Through applying active teaching and learning we created an example of the theory on students' activities. This approach also links students' real world experiences to the content of the course, which allows them to put theory into context. Teachers especially appreciated the interaction with the students, the depth of the discussions, and were impressed by the steep learning curve of the students. Students enjoyed the freedom to operate, the frequent feedback sessions and the application of theory into practice. For the next year the lectures will take into account that 'minor' students do prepare well for their classes.

Keywords. Active teaching, active learning, BSc., geo-information, digital twin

1 Introduction

Active teaching and learning is the way forward in educating students in geographical information (GI). At TU Delft a new approach has been implemented in the BSc minor Spatial Computing for Digital Twinning (15 ECTS). This minor, as part of the BSc. programme of Architecture, Urbanism and Building Sciences of the Faculty of Architecture and The Built Environment, focuses on formulating and solving complex spatial decision problems in spatial decision-making at various geographical scales. It involves acquiring 3D data, addressing open urban geo-data governance (data sharing by involved actors), developing analytic procedures and simulation models using geo-data for understanding the complexity of cities, landscapes and regions and directing interventions for yielding (objectively evaluated) effective results. Twenty BSc. students from four faculties (Architecture and The Built Environment, Civil Engineering and Geosciences, Aerospace engineering, Computer Science) enrolled into the minor. All students are in their third year of the BSc. program. Few of them had used QGIS or ArcGIS before, but the none of them had previous experience with using 3D geo-information.

Within the minor, the 5 ECTS course Open Urban Data Governance provides a general insight into the relevant legislation and regulations as well as organizational aspects involved in the collection, processing, provision and use of digital datasets in the built environment. In small groups, the students do research to answer a specific social sustainability related question in a city context using open urban (geo) data, while developing a critical attitude towards urban data.

1.1 Objective of the paper

This paper aims to provide an overview of the experiences of the active teaching and learning approach by teachers

and students in the newly developed open urban geo-data governance course. It explains the theories behind the set-up of the course and shares the lessons learned from the experiences of both students and teachers. Case study research on the practise of active learning and teaching within the field of geo education is very limited (Pereira & Oliveira, 2004; Caesar, et. al. 2016). Therefore we hope sharing these experiences adds to the body of knowledge.

1.2 Reading guide

After a short overview of the theoretical background of active teaching and active learning in section 2, we provide in section 3 a description of the course and its assignments. Sections 4 and 5 discusses the research projects performed by the students and the results. The evaluation of the course itself is discussed in section 6. The paper ends with our conclusions.

2 Active teaching and learning in context (theory)

In a constantly changing world, teachers should rethink teaching methods on a regular basis, reconsider them and adapt to the developments of our society. The aim is to set up a learning environment that supports learning activities that are aligned with the desired learning outcomes (Biggs 2003). Numerous studies question the effectiveness of traditional face-to-face teaching (Bonwell & Eison, 1991; Renkl et al. 2002; Michel et al., 2009). Research shows that students engaged in active learning gain more from their classes compared to traditional lectures (Deslauriers et al. 2019; see also Chi 2009, Meneske et al. 2013, and Freeman et al. 2014).

Although this shows that active teaching and learning has been around for many years, it is surprising to see so few elaborate on the topic for geo education. There may be best practices, but reports or scientific publications in the field of geo data education are not that common. Also for secondary education attention is necessary. The recent Eurydice report (European Commission 2022) shows that in the EU at the primary and secondary levels (geo) data education in many western EU countries is very limited. However (Pitz et al., 2021), a report for the Erasmus+ project "open SPatial data Infrastructure eDucation nEtwoRk" (SPIDER) on active learning and teaching, builds on theories, methods and best practises on active teaching and learning in the domain of open SDI's. While preparing the course, the teachers made extensive use of these findings.

2.1 Teaching methods

Active teaching refers to methods that dynamically involve students in the learning process (Meneske et al., 2013). The methods used can be diverse, e.g., role-play, group work, presentations and debate. Active learning is associated with an entire system of activity involving the teacher, the student, the teaching materials, software, and the physical environment (Chi, 2009).

By integrating the students into the teaching process itself, the result will be that the students, consciously, but often subconsciously guide the lessons. The teacher therefore adopts the role of a mentor: providing guidance to students towards acquiring knowledge, while the students themselves build on knowledge of others, e.g., co-students and teachers, to incorporate this knowledge into their own bank of knowledge.

The active teaching and learning process consists of three stages:
1. Orientation,
2. Active processing, and
3. Evaluation and feedback.

Orientation

The orientation phase aims to motivate students to actively participate in the teaching and learning process. Motivation can be considered as the amount of effort a person is willing to exert in pursuit of a goal (Keller, 2006).

Active processing

Active processing refers to the learning activities themselves. Through these activities, students are engaged with the content, leading to the construction of knowledge. Because students actively process information, they remember, understand, and acquire the relevant knowledge.

Evaluation and feedback

The active teaching and learning process does not end with the processing stage. The stage of evaluation and feedback is also crucial in activating the students, even after the learning activity itself. This third stage deals with discussing the outcomes of the learning activity with students Feedback is an essential aspect of active teaching and learning, and therefore when planning education enough time should be foreseen for evaluation.

In the course we implemented the three stages of the active teaching and learning process:
1. Orientation,
2. Active processing;
3. Evaluation and feedback.

2.2 Data and Software Availability Section

No data or code was collected, developed, or used in this work. Two student groups uploaded their final report into the TU Delft Education Repository (https://repository.tudelft.nl/).

3 Active teaching and learning in practice

Next to interactive lectures, the course Open urban data governance implemented several active teaching and learning activities. In this section we describe the assignments and provide the results of the activities.

The three active teaching and learning activities in the course are:

1. Lectures in which the (preliminary) results of the projects were leading the discussion on the subject matter.
2. The assignment to create a map of noise levels of a part of TU Delft campus (field work, presentation and report).
3. The assignment to design a governance framework for optimal use of data in order to find solutions for a self-chosen societal challenge in the city (paper and presentations).

3.1 Interactive lectures

The interactive lectures concerned two parts: (1) lecturing a specific topic: Digital Twinning concepts, the legal framework (open data, freedom of information acts, copyright, database protection, data protection), Ethics and Data quality (Findable, Accessible, Interoperable and Reusable (FAIR) data, dark data, black data), and (2) student presentations of preliminary results or plenary and private discussion of drafts of the paper with the supervisors, including written and oral feedback on the draft.

In the interactive lectures the teachers used various strategies including four corners (a central question and four answer options, each corner represented an answer option), quizzes, pairing (discuss in pairs possible answers), and one sentence summary (e.g., summarise in one sentence this lecture). In the draft paper sessions the teachers summarised their main perception of the submitted drafts, shared commonly experienced challenges and opened the discussion on such challenge. They tried as much as possible to link the challenges they experienced to the theory presented in the lectures.

3.2 Create a map of noise levels of a part of TU Delft campus

The course started with a general introduction into data and digital twinning and the announcement for the first assignment for the second day of the course. In this *orientation* stage of the assignment, the teachers tried to make the assignment more appealing by taking as an assumed starting point that 'TU Delft has the ambition to become the most silent university of the world', which adds context that also makes the research feel more relevant.

> **Assignment 1**
> TU Delft has the ambition to become the most silent university in the world. The board of the university would like to know what the current noise levels on the campus streets are. They are especially interested in the levels between 9am-10am on Thursdays.
> Assignment: provide in groups of two an overview of the noise levels for a to your group assigned area on our campus. Document your strategy and your results and share them in a brief report in the education platform.
> Tip: you may want to check noise recordings apps collecting noise levels on TU Delft campus.

Announcing that the task was coming from the board of our university added into the 'playful' vibe which was also created with using a PokeGym as meeting point, which made the assignment more fun, but also served to illustrate the interaction and tension between augmented reality and real world activities.

Figure 1. Picture of the meeting point as communicated to the students, using OpenStreetMap and a screenshot of Pokémon Go showing the PokeGym in front of the Faculty building.

Active processing

In this assignment students were tasked to:

1. collect data on noise levels at TU Delft campus,
2. document their strategy and results, and
3. discuss critically the results presented.

Students had two hours for these tasks on Thursday morning. No further instructions were given, so they had to decide for themselves what to do and how to do it. In the third hour the groups presented the results to their peers and mentors in the class room.

Findings

Back in the class room it became clear each group applied a different strategy for the collection, processing and presentation of the work (see table 1). All groups used a noise level recording app, but the measurement strategy varied: both in the equipment (measurements with one app on one cell phone, versus one app on two cell phones), where they measured (measurements in limited fixed points, measurements every other 10 meters, continuous measurements along the roads), and for how long (seconds per point, minutes per point, continuous), and the choice of the measurement (average, highest/ lowest value).

chose their own way of presenting their results (see figure 2). Background maps were sourced from Google, the national mapping agency, OpenStreetMap and TU Delft. The presentation of the noise level depended on the measurement strategy: noise levels per fixed point, or continuous. Some groups interpolated between measurements. Most groups added a legend, but none of the groups added an orientation (e.g., north arrow) to the map.

Evaluation/ feedback session

At the evaluation and feedback after the field work and presentation of the results the following general observations and conclusions were made by the students:

1. both technical and organisational skills are required to answer the research question;
2. organisation of the research question is necessary (both from client and student side): specify the instruments, research strategy, format of end

Table 1. Overview of groups and approaches to collect noise data.

Group	Strategy		
	Collection	Processing	Presentation
1	Measurements in 3 fixed points (most crowded place). Use of the same app in two phones	Not specified	Highlighted area on Googlemaps + a table with measurements
2	One Samsung A52 smartphone, every 30-40m measure for 30 seconds and take the average	QGIS	Map with scaled measurements per 30 seconds
3	Decibel X app (after trying 5 noise apps), watched videos on accuracy app; 2 different phones (android & iPhone)	Average measurement in 5-10m circle, 10 minutes per circle, 3 circles for the area	Map with circles with noise distribution
4	NIOSH Sound Level Meter; one iPhone SE; GPS essentials on Android 12: select quiet spots, 1 minute measurement	Add coordinates to the noise levels	Aerial with per spot 1 minute average scaled
5	Samsung Galaxy A50 (Android 11); Physics Toolbox Suite; 12 walking lines; 130 cm above ground level	ArcGIS Pro; Twelve csv files; manually position added (based on the map)	Aerial of measurements
6	Decibel Meter app; measurements at 'representative points' in the area	Manual	List of data
7	iPhone XR, Decibel Meter app; Every 15-20 m one measurement for 10-20 seconds	Noise levels manually noted	Map with scaled measurements per 15 seconds
8	Soundmeter app	Not specified	Map with noise level points, no legend
9	Noise Capture app; walking in the area with consistent speed;	Not specified	Map with continuous measurements, legend and pictures of the locations

Also in the processing of the data the students applied different strategies varying from inserting the data in QGIS or ArcGIS Pro, to Manual reporting of the measurements of the app. Not surprisingly all groups

3. result etc.;
4. coordination among the groups is required to achieve necessary standardisation in results;

5. one group of students used the same app in different smartphones and found that "The quite big differences between our measurements were surprising";
6. Students acknowledged that "one measurement is no measurement";
7. the need of calibration of recording instruments was noted;
8. causes for the noise levels are potentially manifold (behind a building, noise screens, trees, glass bin, construction works, cars, wind direction);
9. how to present your results (e.g., using cartographic standards);
10. ease to collect might be a factor influencing the quality of the results (weather conditions, access to terrain);
11. accuracy of GPS for this purpose might not be sufficient;
12. the need to consent to user conditions (privacy statement of the developer) to be able to use the app.

3.3 Write a paper on your experience in answering a societal question concerning the urban environment

In the main assignment of the course the students were tasked to develop a societal relevant question on the urban environment, to answer this question with the use of geo data, to assess the FAIRness of the data and to critically reflect upon the research results. This should be presented in a paper of max. 5,000 words.

The students were divided in groups of two or three students. Each group suggested a topic of their choice (*orientation*). Based on the topic they developed a research question.

The topics and research questions were:

1. What are the effects of wind speed and precipitation on student commute times?
2. To what extent can green and water structures cool urban landscapes?
3. Where in Delft is the noise standard for traffic noise exceeded, which physical factors of the roads have an effect on the noise exceedance and what measures could be taken?
4. What is the impact of the port of Rotterdam on the air quality of the city of Rotterdam.
5. What is the effect of trees on the surface temperature in Delft?
6. What is the most suitable place to study on TU Delft campus?
7. What is the effect of different types of vegetation on the urban heat island effect in the historic city centre of Delft?
8. Where in Utrecht can new social housing projects best be developed?
9. What is for students the most satisfying location to live in Delft?

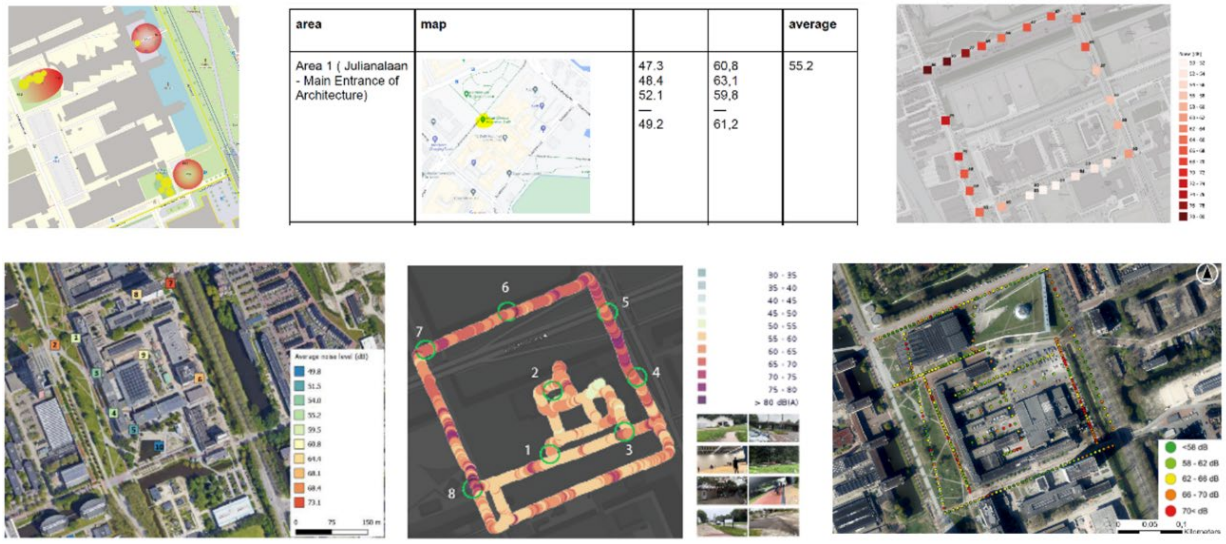

Figure 2. Example presentations of the final results of the first assignment.

After the general discussion, we discussed whether or not the central question of the assignment was answered by the work of the students. The central assignment was: "The board of the university would like to know what the current noise levels on the campus streets are. They are especially interested in the levels between 9am-10am on Thursdays." The group agreed that they had not sufficiently answered the question of the board. The applied strategies were too diverse both for the collection, processing and presentation of the results. Upfront coordination resulting in an agreed strategy to be applied by all was the concluding solution of the group.

3.4 Strategies applied (*active processing*)

The students followed different strategies to obtain the data needed to answer their question:

1. The following strategies were employed to obtain data:
    a. Through internet search engines
    b. Through geo/open data platforms
    c. Through personal contacts, including those of the mentors
    d. Through a public records act request (the Dutch Freedom of Information act, *Wet Open Overheid*)
    e. Through collecting data themselves
    f. Through sending out surveys

2. The following strategies to analyse data were used:
    a. Study software packages to analyse and present the data.
    b. Involve experts users for support.
    c. Involve university staff for use of software packages for which the university has licences.

4 Project results

Few of the projects managed to answer their research question satisfactorily. However, the course and assignment appeared to be a great learning experience for the students, therefore illustrating the saying that failure is part of the process to success. In the final part of the assignment students had to evaluate their answer to the research question and assess the FAIRness of the data obtained.

4.1 Answering the research question

Table 2 provides an overview by listing whether the research question could be answered, and the main issues experienced by the students. Several of the issues experienced we explain here in more detail.

Table 2. Overview of main results of the student groups

Group	Question answered?	Issue(s)
1	No	No access to data despite open science policy
2	No	Lack of interoperability in data and software
3	Yes	Asking the right question in a public records act request
4	No	Dark data/ incomparable entities
5	Yes	Semantics on (surface/ air) temperature/ availability of temperature data
6	No	No theoretical basis provided
7	No	No proper research question was developed
8	Yes/No	Dark data; lack of up to date data
9	Yes	Response rate

No access to data despite open science policy (Group 1)

The group found that the data was not clearly findable, and that the authorisation process for acquiring the "open" data was unreliable and bureaucratic Firstly, it was uncertain whether the required data set existed or not, until further contact with data providers. Secondly, the protocol of being able to access the data was unspecified. Thirdly, once contact was achieved, it was found that communication with data handlers was unattainable after a certain point, which prevented in the data being accessed at all.

Lack of interoperability (Group 2)

The group was unable to answer the original research question. This forced them to dive into a totally different kind of research and to find what was causing the errors encountered and understand what these meant. This pushed them to focus on a far more technical and practical side of not only the datasets, but also the techniques behind the software packages used. All unsolved challenges could be traced back to a lack of interoperability, both in data and in software.

Public Records Act request: asking the right question (Group 3).

This group worked on the research asking whether inhabitants of Delft experienced noise exceedance caused by traffic. They discovered there was no information available on the physical aspects of the car roads in the city of Delft. So they submitted a public records act (*Wet Open Overheid*) request to the city of Delft. In the request the group asked the information about the different types of asphalt used on the roads in the city centre of Delft. The request also states that they would like to receive "information about the type of pavement and the types of asphalt that are currently (2022) present on the roads within the municipality of Delft. This concerns the provincial roads within the city and the national roads that surround the city (A13, A4 and N470)". By doing this, they may have caused confusion among the people handling the request, because it was unclear what the request was about. Therefore, a second mail was sent specifically requesting information about the roads managed by the Municipality Delft. This culminated in a

phone call where the civil servant claimed that the municipality was not responsible for this data. After responding that they are responsible, the civil servant promised to look further into it. The group has not been in contact with the municipality since.

Dark data: not being able to include all trees of an area (Group 8)

Group 8 was able to use a publicly available dataset on trees. However, this concerned only trees and lower vegetation in the public space. Datasets with information about this in private areas were unavailable to the students. Their research question "What is the effect of different types of vegetation on the urban heat island effect in the historic city center of Delft?" was answered with this bias in the available data. This phenomenon of answering questions with incomplete data is so called dark data (cf. data invisibles in Noveck, 2017).

4.2 FAIR data assessment

As part of the paper assignment students also had to assess the FAIRness of the data they obtained and used. FAIRness refers to the **F**indable **A**ccessible **I**nteroperable **R**eusable (FAIR) Guiding Principles of Wilkinson et al. (2016) (see figure 3).

The European Commission has the following recommendations in order to make data FAIR. Findability requires for the data to be searchable, and to be recognizable through metadata and an identifier. This allows users to identify that there is an existing data set, and to assess its relevance through the metadata.

Accessibility is defined as the ability for users to use a protocol in order to access the data. The protocol shall use the identifier of the data set, shall be free, and shall allow users to be authenticated to access the data when necessary. For data to be interoperable, the regulations focus on both the data and metadata to be written in vocabulary which is formal and understandable for a wider audience, and also references to other data which can be relevant for the research domain. Finally, the reusability of data is determined by having both the data and metadata be described in domain-relevant standards, and for it to be described in various keywords which relates to its findability in research.

Table 3. Overview of data FAIRness in project results

Group	FAIR data?	Issue(s)
1	N	No access to the data
2	Y/N	Some datasets were FAIR, others not
3	Y/N	Some datasets were FAIR, others not
4	Y/N	Some datasets were FAIR, others not
5	Y/N	Some datasets were FAIR, others not
6	N/A	
7	N/A	
8	N	None of the datasets was FAIR
9	N/A	

Box 2 | The FAIR Guiding Principles

To be Findable:
F1. (meta)data are assigned a globally unique and persistent identifier
F2. data are described with rich metadata (defined by R1 below)
F3. metadata clearly and explicitly include the identifier of the data it describes
F4. (meta)data are registered or indexed in a searchable resource

To be Accessible:
A1. (meta)data are retrievable by their identifier using a standardized communications protocol
A1.1 the protocol is open, free, and universally implementable
A1.2 the protocol allows for an authentication and authorization procedure, where necessary
A2. metadata are accessible, even when the data are no longer available

To be Interoperable:
I1. (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.
I2. (meta)data use vocabularies that follow FAIR principles
I3. (meta)data include qualified references to other (meta)data

To be Reusable:
R1. meta(data) are richly described with a plurality of accurate and relevant attributes
R1.1. (meta)data are released with a clear and accessible data usage license
R1.2. (meta)data are associated with detailed provenance
R1.3. (meta)data meet domain-relevant community standards

Figure 3. The FAIR Guiding Principles

In the discussions on the FAIR Guiding Principles the class concluded that these should be improved to fully satisfy student user needs. Especially the aspects of financial accessibility and intellectual accessibility (see Van Loenen and Grothe 2014) need to be included to provide a more realistic assessment of the extent to which a dataset is ready for use by students. Also the amount of time required to obtain a dataset should be included in the framework (e.g., four weeks waiting time after a request for data was submitted). An interesting note from the student work was that even if the (meta) data is fully complying with the FAIR principles the data may still not be useful because different software package do not comply with the FAIR principles. This implies that similar principles need to be developed for software in order to allow for a proper assessment of the FAIRness of the system from a user perspective.

5 Evaluation of the course

5.1 Theory matching practice and vice versa

Teachers especially appreciated the interaction with the students, the depth of the discussions, and were impressed by the steep learning curve of the students, especially of those without a 'geodata background' that trained themselves through online tutorials.

The lessons learned for next year are:

1. No groups of two. If one student drops the course the group work becomes individual work.
2. Create as much as possible mixed groups, e.g., Dutch & international students; data savvy & data layperson. Adding a Dutch speaking person to every group is also important because the datasets are difficult to find and are often given Dutch titles and metadata.
3. Students in a minor are highly motivated students that prepare themselves for class. Lectures should not describe or repeat the study material, but should analyse, discuss and apply the theory

5.2 Student evaluation

During the evaluation at the end of the course, the students were very positive. For some it was even " the best course of this BSc".

Students enjoyed the freedom to operate i.e. to pick a topic and design and implement a strategy to answer the question), and the application of theory into practice.

Student: "*Undoubtedly, this experience opened a new door for me. I now view, use and interact differently with data and software, whereas before this course, I was completely oblivious of its importance. In addition, the FAIRness principles, of which I had never heard before, were a big eye-opener for me and have changed my way of approaching questions / problems / research significantly. Lastly, I now believe I am way better equipped to tackle future endeavours in my field after this course, because I have a general understanding of these newly acquired concepts that undeniably will be necessary in the digital time that is ahead*".

Student: "*From this course, I was able to see the importance of data in society and what issues occur when working with data. Firstly it gave the opportunity to reflect on an impactful topic for society which is relevant to my education as an engineer. This has led to me reflecting and considering the role of my technology-oriented education, and possible future profession, and how it can change the future of society. This includes topics such as dark data, AI in the city, and personal data. This is something I consider to be extensively lacking from other parts of the Bachelors curriculum. Secondly, I've gained an intuition on how data works in a project, and the possible issues arising in interoperability of data which has already impacted how I see information and data being handled in other projects. Thus, providing also great value to the technical part of my education."*

Student: "*I also really liked the interactiveness of the classes. Implementing moments in the lecture where we had to discuss something with each other and then with the teachers and starting a subject by asking our thoughts about it, writing them on the whiteboard and afterwards giving the real explanation and generally asking lots of questions to the class gave the opportunity to think for yourself first. This kept the class active and stimulating. I would have liked to see even more in depth discussions about the literature for the week*".

Student: "*We truly enjoyed the freedom given by the mentors to find a research topic we found interesting ourselves. Personally, I noticed this increased my interested and motivation to work on the project greatly. Playing into the personal interests of students will make the projects feel more personal and will increase eagerness to learn more and to go the extra mile when it comes to writing about the project. Furthermore, the encouragement of submitting the public records request was a great stimulants to look into a topic we would otherwise only have encountered much later in life. It also gives insight into the way data is released, including giving a better feel for who is responsible for a specific part of the city*".

Student: "*As a student, I really like the freedom to operate. It was intriguing to do research on your own chosen topic and be able to put theory into practice. I was inspired to put a lot of work and effort into the project*

since I got to choose my own research question, and the topic truly interested me."

The frequent feedback moments were very appreciated:

Student: "*The weekly feedback was quite extensive and the in person discussion of the feedback worked clarifying. It helped to know how your paper was doing at the moment and gave good opportunities to ask questions*".

Student: "*The feedback sessions (...) really helped, also because the given feedback was very specific, giving direct stepping stones to work further on the project*."

Student: "*These sessions assisted us a lot in the process. The conclusion of our project was that we were not able to answer the research question due to the interoperability of different datasets and applications. At first, we were a bit insecure about the fact that we could not answer the research question. The feedback sessions helped us get rid of this uncertainty and therefore we could accept that the fact that it did not work also was a reasonable conclusion*".

And also the link between recommended literature and the lectures was acknowledged:

Student: "*Personally I really enjoyed the chosen literature to read. It was clearly connected to the lectures and had a nice ratio between information density and readability, as in a lot of information is given but not in a dry textbook way*".

Next year the lectures will take into account that students do prepare for their classes. A peer review process might be included since the teachers also received critical feedback about the usefulness of such a peer review.

Student: "*For next year I would advise also offering a more in-depth law class explaining some basics. More students thought this was highly interesting and would like to learn more. Also, I am not sure a peer review is a much needed addition to the course since this usually ends up as being more work for students. Additionally, and this may not be in the scope of giving this course, but I personally would have benefitted from a lessons about academic writing*".

6 Conclusion

Active teaching and learning has gained significant traction in the geo domain. Although earlier research is limited it concludes that this approach of education is often better appreciated by the students than traditional education methods (Pereira & Oliveira, 2004; Caesar, et. al. 2016). Indeed the implementation of active teaching and learning methodologies in the TU Delft minor Spatial Computation for Digital Twinning was highly successful both from a students and teachers perspective.

Through the active teaching and learning students activities theory is exemplified and linked to the real world experiences of the students which allows them to put the theory in context. For example, students experienced having the right to request a dataset for reuse is something else than actually using this right in practice. Students also were confronted with organisations that do preach open science while in practice collected data is not (openly) available. These experiences would not be the same if the students would have been provided the data by the teachers.

Students reflected on having both a stronger theoretical understanding of data's impact on society, as well as practical knowledge on how to use it for their education and future professions.

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